BNFL Inc.

Executive Summary

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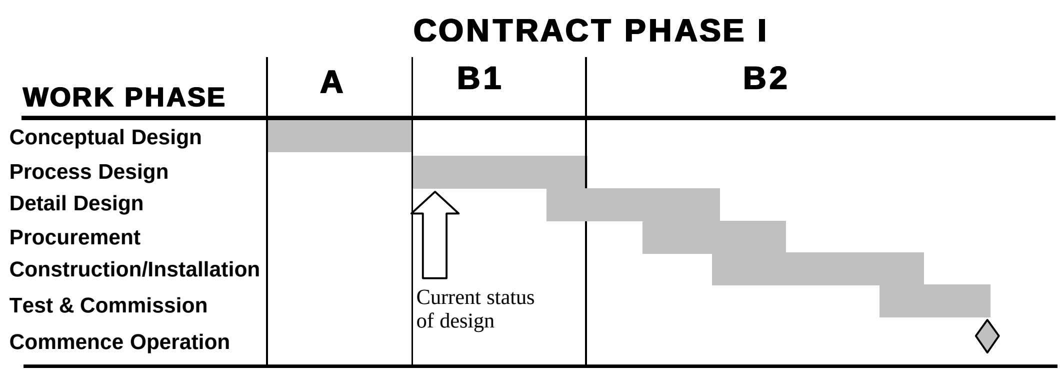
Executive Summary

Background

Privatization Contract

BNFL Inc. has entered into a contract with the US Department of Energy (DOE) for pre-treatment and immobilization of approximately 55.5 million US gallons of radioactive waste currently stored in underground tanks at the Hanford Site. This contract specifies the DOE will retrieve and transfer low-activity waste (LAW) and high level waste (HLW) to facilities designed, built, and operated by BNFL Inc. for pretreatment and immobilization. The DOE identifies this approach as Privatization. Privatization services will be provided in two phases. Phase I is subdivided into Parts A and B. Phase I, Part A was completed in 1998 and consisted of a technologies demonstration, a conceptual design, safety and regulatory licensing, and a financial plan. Phase I, Part B is divided into Part B-1 and B-2. Part B-1 will be effective from August 24, 1998 through August 23, 2000, after which time Part B-2 will commence. During Part B1, BNFL Inc. will confirm the design to about 25 – 30 percent complete, and start licensing activities for the contractor's facilities. Figure ES-1 shows the current design status relative to the Part B design, construction and operational startup schedule. For this deliverable, the design is about three percent complete.

Figure ES-1. Current Design Status



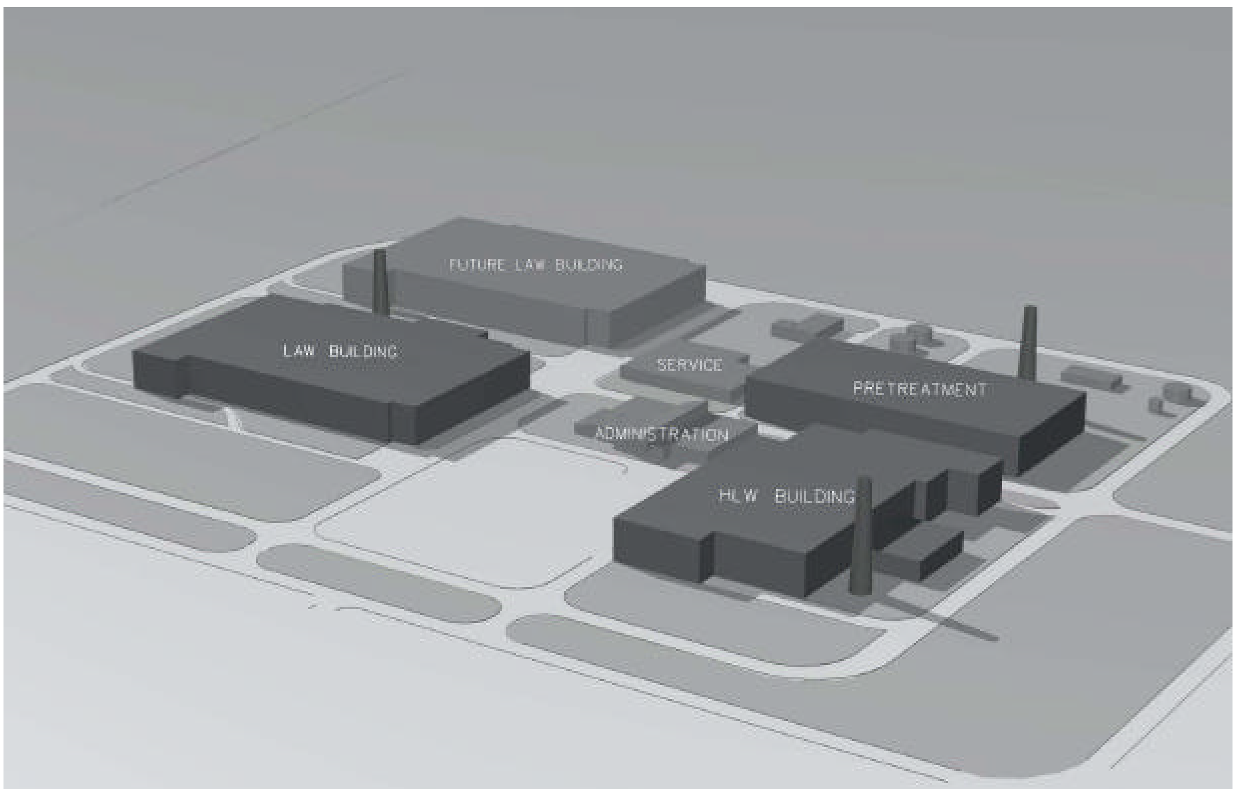
Environmental, Safety & Health Program

BNFL Inc. considers that none of its activities is more important than the health and safety of its employees, its contractors, the general public, and the protection of the environment. As a minimum the company will comply with all relevant legislation and in some cases may go beyond legal requirements. The company will: ensure that its operations are performed, and can be seen to be performed, safely and endeavor to prevent accidents and to minimize, as far as reasonably practicable, the consequences of any accident which may occur.

Facility Description

The TWRS Privatization facilities will occupy approximately 55 acres of land in the 200-East Area of the DOE Hanford Site in Richland, Washington. Most of the TWRS-P hazardous operations will be contained in the process buildings, which are divided into three major areas for pretreating and immobilizing tank waste. The overall dimensions of the LAW (low activity waste) building are approximately 500 ft (150 m) long by 200 ft (60 m) wide by 115 ft (35 m) above grade. Shielded cells that contain the storage and process tanks, and other process vessels are located below grade in the pretreatment area. The pretreatment and HLW (high level waste) buildings are somewhat larger than the LAW building. Other smaller support buildings and processes are also important to safety. Figure ES-2 provides an overview of the facility layout.

Figure ES-2. Overall Facility Layout



Process Description

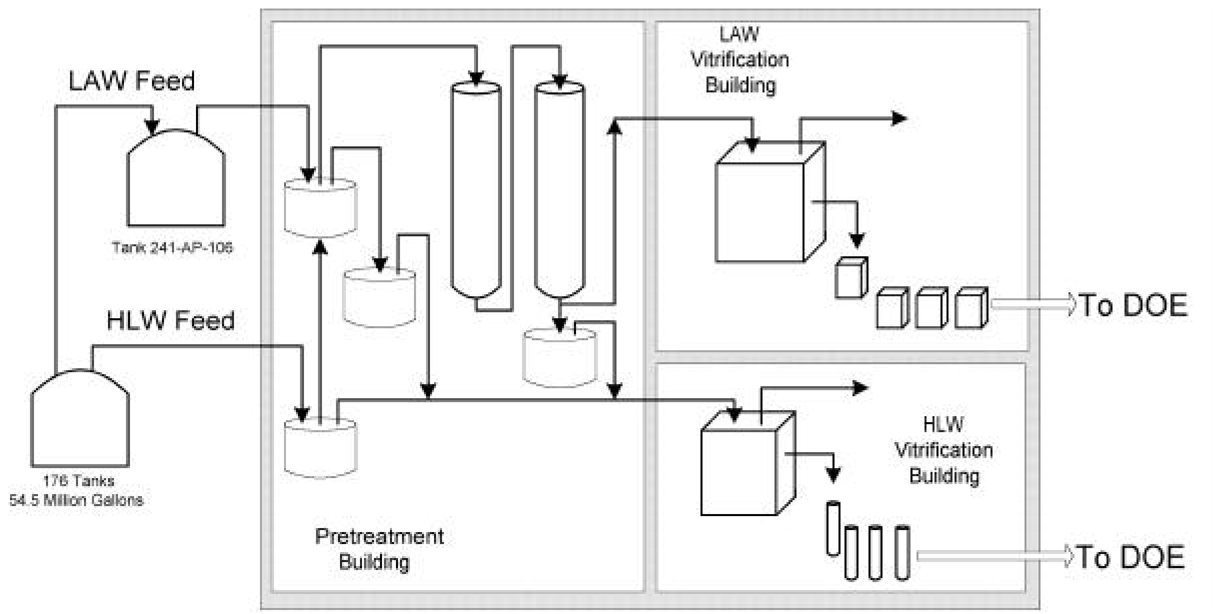
The TWRS-P facility will contain processes (Figure ES-3) for pretreating and immobilizing both LAW and HLW. For LAW, entrained solids are first removed, and then Strontium/TRU, Cesium, and Technetium are removed and temporarily stored for later mixing with HLW. The remainder of the LAW is then mixed with glass forming materials and immobilized by vitrification. The HLW is first dewatered then mixed with the Strontium/TRU, Cesium, and Technetium from the LAW pretreatment, mixed with glass-forming materials and then vitrified.

Design Safety Features (DSF) Deliverable Requirements

Scope and Content

The Part B-1 contract requires a Design Safety Feature (DSF) deliverable at six months from authorization. It is understood for the purpose of this deliverable that DSFs are those aspects of important to safety (ITS) structures, systems or components (SSCs) that give assurance that the SSC will perform its safety function. The scope and content requirements for the deliverable were determined in working meetings between BNFL Inc. and the DOE Regulatory Unit (RU) and documented in DOE letter 98-RU-0329. During development of the scope and content, it was agreed that BNFL Inc. would submit two categories of information that would demonstrate the listed elements in the scope document. These elements comprise the integrated safety management (ISM) process to be used for the identification of the required DSFs.

Figure ES-3. Process Flow Schematic

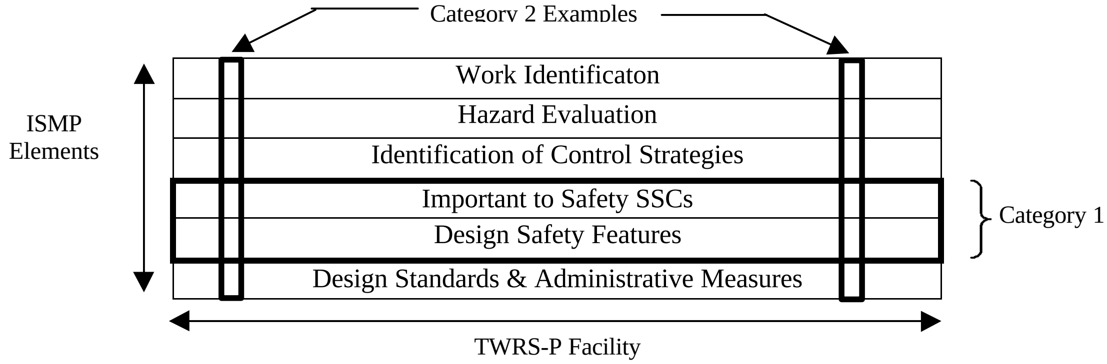


The first category provides a description of planned ITS SSCs and associated DSFs intended at the date of the submittal, based largely on experience.

The second category is information that provides ten representative examples of application of the ISM process, each encompassing only one selected specific hazardous event sequence. The relationship between Category 1 and Category 2 is shown in Figure ES-4.

Because this deliverable is based on a design that is between conceptual and preliminary, it will not be included as part of the Authorization Basis unless requested by BNFL Inc. and approved by DOE RU.

Figure ES-4. Relationship of Category 1 and 2 Information



Compliance With Requirements

The three formal DOE documents that form the primary basis for this deliverable are 98-RU-0329 which describes the scope and content, DOE/RL-0004 which describes the process, and DOE/RL-0006 which contains top level standards and principles, including defense in depth. The scope and content document contained several specific requirements that were used in the preparation of this deliverable. Clarification of requirements was provided in working meetings between BNFL Inc. and the DOE RU. This deliverable complies with all requests to the extent practical given the design is about three percent complete.

The BNFL Inc. procedure K71P505, *Safety Standards and Requirements Identification* is the implementing procedure used by BNFL Inc. to identify standards and requirements and is derived from DOE/RL-96-0004 via our implementing standard. A detailed discussion of each step in K71P505 is documented in the Category 2 portion of the information. The applicable top-level standards and principles from DOE/RL-96-0006 are utilized during development of control strategies for Category 2.

The information in this deliverable is based on the November 23, 1998 Basis of Design for the TWRS-P facility which is subject to change as the design progresses. The Basis Of Design includes the change from one main process building to three main process buildings and the provision to separate a combined B and D waste stream into its respective waste streams. Additionally, this deliverable addresses changes from Part A associated with new design concepts for equipment, as a result of breakthrough studies by BNFL Inc.

Evaluation of Radiological Events

For purposes of this deliverable, normal operations and accident scenarios (events) have been considered for identification of SSCs and DSFs. A radiological event can be defined as an accidental occurrence within the processing facility wherein direct radiation doses have increased or where a release of radioactivity has occurred within the confines of the processing facility and possibly to the environment. For radiological events, BNFL Inc. uses potential adverse consequence of the event and frequency of occurrence to guide development of methods to minimize the impact of the events on three specific groups: the facility worker involved in the process at the time of the event; the co-located workers within the facility; and the public. Control strategies are determined that serve to prevent or lower the consequence levels to meet regulatory requirements. Then, reliable ITS SSCs are selected to ensure events with potential consequences above risk limits are not credible.

Evaluation of Hazardous Chemical Events

For hazardous chemical events, BNFL Inc. performs a process hazards analysis using acceptable industry practices as prescribed in 29CFR1910.119. For the offsite public and the worker, the projected exposure is compared to the standards in *Emergency Response Planning Guide-2* (ERPG-2). If the chemical release standard is not satisfied, the need for engineered or administrative controls to prevent or limit the release is addressed in accordance with standard industry practices.

Description of Approach to Implement Defense In Depth

Defense in depth is a safety design concept or strategy that will be applied at the beginning of design activities and maintained throughout the facility life. This safety design strategy is based on the premise that no single layer of protection is completely relied upon to ensure safe operation for operations with the higher hazard levels.

Category 1 – Planned Design Safety Features

Selection of Structures, Systems, and Components, and Associated Design Safety Features

Important to safety structures, systems, and components and associated design safety features that are known, expected or reasonably likely were identified. They were documented in comprehensive descriptions and/or lists that include sufficient description of system and structure operations to understand the purpose of the design safety features. The descriptions and lists were based on the existing TWRS-P design and BNFL experience with similar facilities. The final selection of ITS SSCs will be performed in accordance with the BNFL Inc. Integrated Safety Management Plan which will take account of the results of consequence and frequency analysis.

All presently identified structures, systems and components were initially considered to have the potential to be classified as ITS. Teams of design and safety personnel then identified potential faults of these systems which had the potential to give rise to hazardous situations. This fault selection process was based on team experience from assessment work to date for TWRS-P or prior experience with similar systems on other BNFL facilities. They then identified the safety functions required to provide protection against these faults and the SSCs that would provide those safety functions. These SSCs were identified as likely to be ITS. Additions to the list were made by explicitly considering internal/common cause hazards, natural phenomenon hazards, normal operational (i.e., non-fault) hazards, and criticality.

In order to ensure that the listing of ITS SSCs was as complete as could be reasonably expected, the ISAR was reviewed for ITS SSCs, the HAR was reviewed for identified hazards and implied ITS SSCs (safeguards), and the Category 2 Information was reviewed for ITS SSCs and their DSFs. Additionally, a high level screen using HAZOP guide words was used to check for any missing major hazards. Then a "Mini-HAZOP" review of the changes from Part A to the current baseline design was conducted to identify any additional ITS SSCs.

Category 1 Summary Results

The resulting ITS SSCs and associated DSFs were then combined into the ten groups shown in Table ES-1. The arrangement of ITS SSCs into ten groupings is a result of the process used to identify the SSCs, i.e., primarily from experience.

Table ES-1. Groups of Important to Safety Structures, Systems and Components

Groups of SSCs	Typical SSCs	SSCs	DSFs
1. Shielding and Confinement	Cell structures, vessels, piping and gloveboxes	55	155
2. Ventilation Systems	Fans, ducts, dampers and filters	186	327
3. Electrical Systems	Transformers, switchgear and wiring	8	27
4. Instruments and Control Systems	Sensors, alarms and controls	57	68
5. Utilities and Services	Cooling water systems and cold chemical feed system	80	118
6. Transfer Devices	Steam ejectors, breakpots and reverse flow diverters	27	38
7. Mechanical Systems	Cave cranes, bottom entry flasks and power manipulators	24	84
8. Unit Operations	Evaporators, HLW melters, and ion exchange columns	67	91
9. Fire Protection	Effectiveness of fire protection systems and barriers	31	33
10. Other Events (external and internal events)	DSFs in SSCs numbers 1. & 2.	33	62
	Totals	568	1003

The numbers of ITS SSCs and DSFs in Table ES-1 is simply the number of entries that are in the respective table in each section of the Category 1 portion of this submittal. This does not represent the total number of SSCs or DSFs that will occur for the final facility. The total number of SSCs in the table is representative of the number of types of SSCs that will occur for the final facility.

For example, in Shielding and Confinement, the subsection entitled Vessels is further divided into specific ITS SSCs, one of which is labeled “Vessels”. This ITS SSC has eleven DSFs. There are estimated to be 53 vessels which are likely to have ITS SSCs because they may require washout. This is based on the Category 2 detail information for Activity Backflow from a Process Vessel into the Vessel Wash Cabinet. Therefore, there may be 53 vessels that are classified as important to safety with the SSC that has eleven DSFs.

Another example associated with counting SSCs and DSFs at this stage of design is afforded by the Uninterruptable Power Supply (UPS). Within the Vessels subsection, the UPS is listed four times, but each is for a different application, e.g., sump overflow alarm. The current approach is to have only one UPS per main processing building (pretreatment for example) but there will be many applications in that building where the UPS provides the necessary power. Therefore, there may be only one UPS that is an ITS SSC for the building but there may be multiple SSCs and DSFs, one for each of the various alarm applications.

Category 2 – Representative Examples

Example Selection

Ten representative examples were selected to demonstrate application of the integrated safety management process to systematically define ITS SSCs and their associated DSFs. They were selected to give the range of consequences and hazard types requested by DOE. The selections were chosen based on assessments in the Hazard Analysis Report (HAR) and the Initial Safety Analysis Report (ISAR) as well as on judgment and experience. The ten examples were proposed by BNFL Inc. and the DOE RU concurred. The ten examples are listed below.

1. Hydrogen Generation in the High Level Waste Storage Vessels
2. Loss of Cooling to the Cesium Storage Vessel
3. Load Drop of a Pretreatment Pump (Out of Cell)
4. High Level Waste Melter Feed Line Failure
5. Cooling Water Contamination
6. Sample Carrier Breakout
7. Low Activity Waste Pipe Break
8. Receipt Vessel Rupture
9. Activity Backflow from a Process Vessel into the Vessel Wash Cabinet
10. Nitric Acid Handling

Category 2 Summary Results

Each of the ten examples demonstrate how BNFL Inc. has applied the ISM process to identify work, evaluate hazards, develop control strategies, and identify standards. Application of the process included consideration of the operating environment, potential faults, unmitigated consequences, event frequencies, control strategy selection from multiple options, setting of reliability targets and performance requirements, selection of standards and administrative measures, defense in depth, and other relevant subjects. The result of the application of the ISM process will be to provide protection for workers, the public and the environment. The design will incorporate defense in depth through multiple mitigation features that include robust ITS SSCs with protective DSFs.

While preparing the assessment analyses for the ten examples, a number of assumptions had to be made about the design and future operations in order to calculate consequences, estimate frequencies, select control strategies, select SSCs, select DSFs and select standards. Table ES-2 contains a brief description of the ten examples and some quantitative data, e.g., the number of SSCs, DSFs, design assumptions (DAs) and operational assumptions (OAs). The 132 assumptions in Table ES-2 will be eliminated by finalizing designs and operational plans during the remainder of Part B.

Table ES-2. Quantitative Characteristics of the Ten Representative Examples

Example No.	Description	SSCs	DSFs	DAs	OAs
1.	Generation of hydrogen in HLW storage vessels due to radiolysis.	17	35	13	2
2.	Boiling of cesium storage tank contents due to the decay heat generated by cesium.	5	18	5	5
3.	Dropped cask with a contaminated pretreatment pump during transport to maintenance facility.	8	10	9	6

Example No.	Description	SSCs	DSFs	DAs	OAs
4.	Breach of glass melter feed line and release of process material into the closed cell.	7	14	6	4
5.	Failure of the cooling coil in the HLW blending tank.	7	12	2	3
6.	Breakout of a test sample from the pneumatic sample transfer system.	9	13	7	6
7.	LAW transfer pipe break between the tank farm and the facility outside the buildings.	6	11	7	2
8.	Rupture of the HLW tank in the closed pretreatment area.	5	13	6	4
9.	Backflow of radioactive material up the water line into the wash cabinet in the closed area.	1	1	1	1
10.	Involves a nitric acid spill and addresses process safety instead of radiological safety.	17	37	17	26
	Totals	82	164	73	59

Summary

The following are summary results from producing this Design Safety Features deliverable:

Mitigated consequences and frequencies, based on application of the ISM process to the ten examples, are well within the acceptable range while using conservative, but reasonably expected, control strategies and resulting SSCs and DSFs. The mitigated results are summarized in Figure ES-5 wherein the representative example numbers are shown in the applicable consequence/frequency block. A conservative approach was used (1.) due to a lack of detail designs and (2.) to ensure appropriate safety features were incorporated in the design.

Extensive use has been made of proven engineering practices established on BNFL facilities processing materials with similar or greater source terms than TWRS-P. As evidence, a comparison of potential unmitigated exposure was made between TWRS-P and THORP. THORP is one of the processing facilities at Sellafield and was one source of experience used to determine SSCs/DSFs for TWRS-P. The comparison shows that the potential unmitigated exposure for a worse case TWRS-P stream is much less than for a near worse case THORP stream. Plutonium is the major factor in the difference. The THORP design incorporates multiple SSCs with defense in depth to prevent hazards from occurring and to mitigate potential adverse impacts should an unlikely release occur. THORP has been operated safely and successfully for about 5 years. Likewise, other major portions of Sellafield which also contain material at risk with similar, or worse, consequences per unit release than TWRS-P have operated safely for over 40 years.

A multitude of SSCs and DSFs were identified during the Category 1 and Category 2 efforts:

	SSCs	DSFs	Description
Category 1	568	1,003	Generic List by Functions
Category 2	82	164	Event Specific List

All ITS SSCs and DSFs for TWRS-P have analogues in place and they are operating successfully in other BNFL facilities, e.g., Sellafield, with only two exceptions and these are for intermediate hazard level operations. The two exceptions are for the melters (including melter in-cell blending systems) and some offgas treatment components. Even for these two, applicable BNFL experience on similar equipment and experience from other TWRS-P team member companies will be used to correctly develop robust SSCs/DSFs for TWRS-P.

BNFL Inc. forged a strong team effort with a tightly integrated group of operations, engineering, and safety personnel during the preparation of the Design Safety Features deliverable.

Experienced staff from BNFL facilities in the United Kingdom and TWRS-P team member companies have been added to TWRS-P to ensure success for this deliverable, the PSAR and other safety and regulatory subjects.

BNFL Inc. has demonstrated the process knowledge and ability to implement the requirements of the ISM process. This is based on the comprehensive analyses and evaluations for the ten representative examples, limited by the current design status of about three percent.

The actual data submitted are preliminary and are likely to change as the design matures.

Figure ES-5. Mitigated Results for the Ten Representative Examples